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(54) **METHOD AND APPARATUS FOR RESTORING MECHANICAL RELAY FROM STUCK FAULT TO NORMAL CONDITION**

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(51) **Int. Cl.**

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H01H 47/22	(2006.01)
H01H 3/00	(2006.01)
H01H 47/00	(2006.01)
H01H 1/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H01H 47/22*** (2013.01); *H01H 1/0015* (2013.01); *H01H 3/001* (2013.01); *H01H 47/002* (2013.01); *H01H 2047/003* (2013.01)

(58) **Field of Classification Search**

USPC 361/160, 170, 179

See application file for complete search history.

(56) **References Cited**

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(57) **ABSTRACT**

Disclosed herein are a method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition. The method may include detecting, by an MCU, a short state or open state of a relay, repeatedly transferring, by the MCU, a current application signal and a current non-application signal to a relay driver when the relay is in the short state, repeating, by the relay driver, an operation of periodically applying an electric current from a power source unit to the relay in response to the current application signal and the current non-application signal so that the release of the contact point of the relay is induced, detecting, by the MCU, the release state of the contact point of the relay, and maintaining, by the MCU, an ECU in an operating state when the contact point of the relay is released.

6 Claims, 4 Drawing Sheets

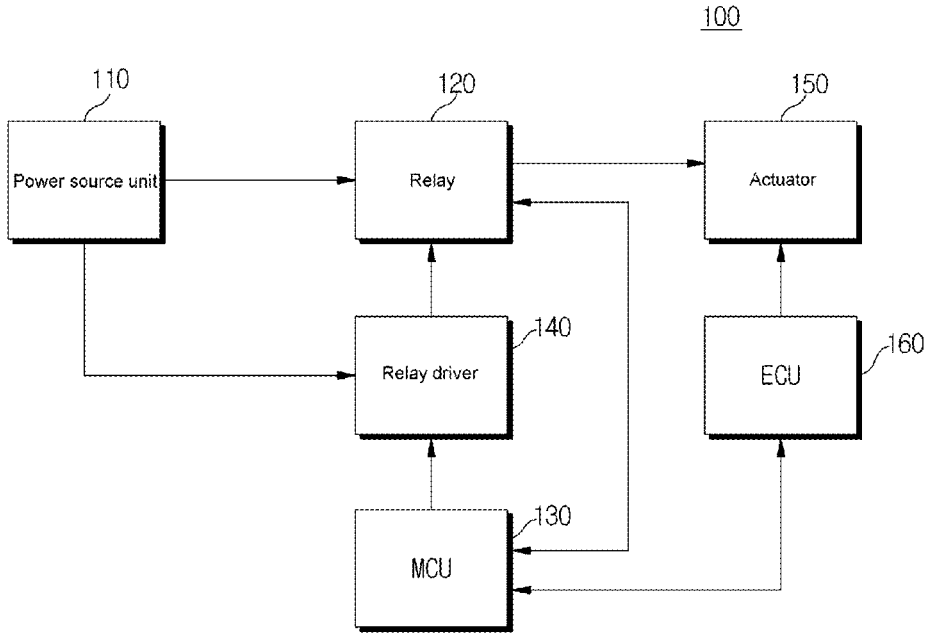


FIG. 1

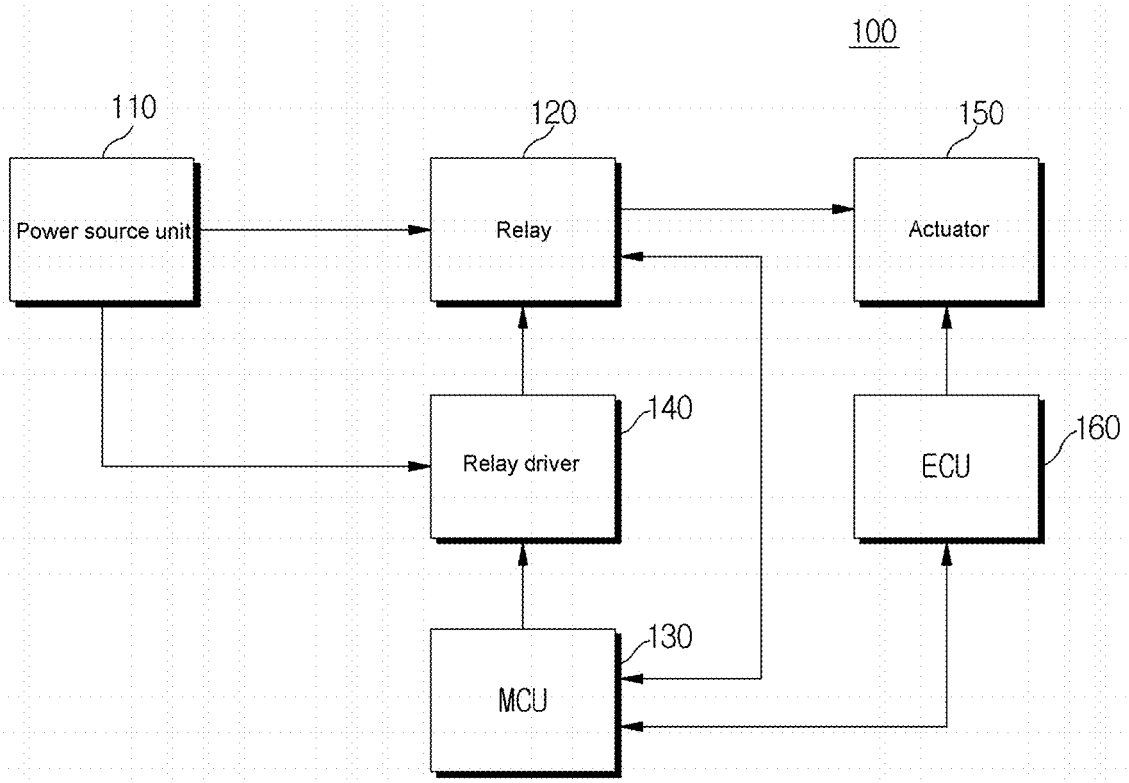

100
110
120
150
Power source unit
Relay
Actuator
140
160
Relay driver
ECU
130
MCU

FIG. 2

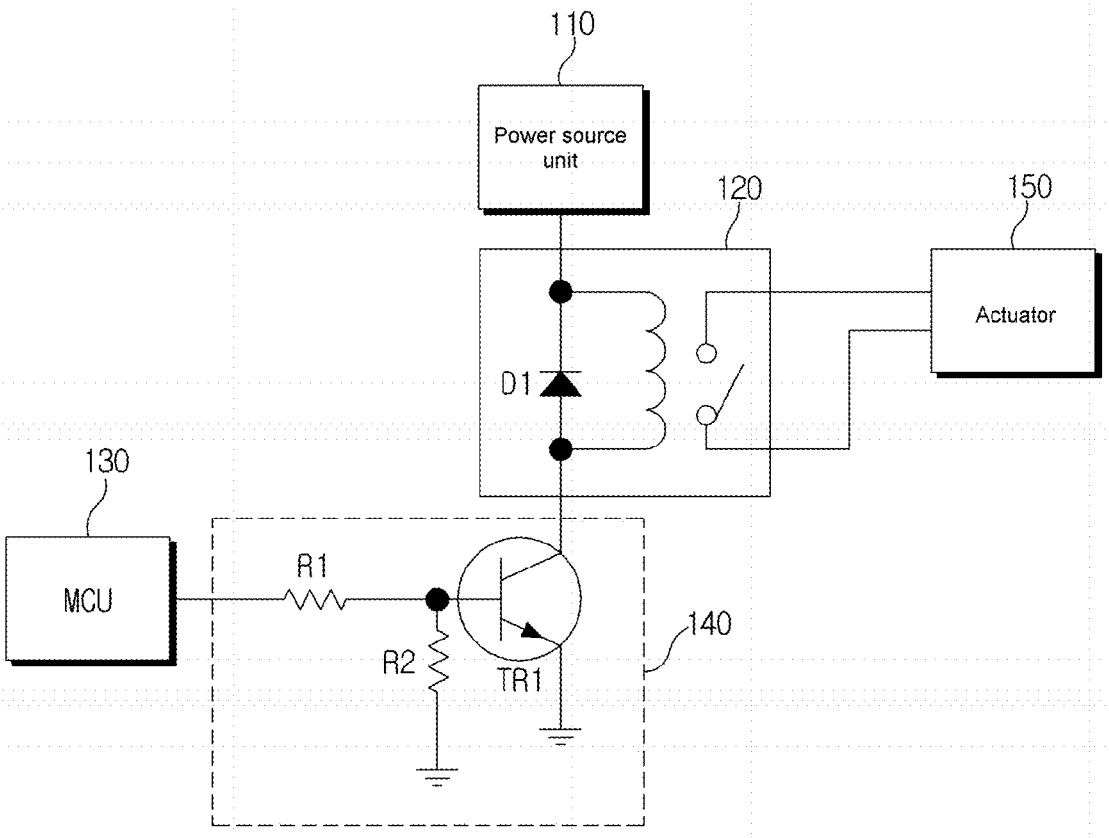

110
Power source unit
120
150
Actuator
D1
130
MCU
R1
R2
TR1
140

FIG. 3

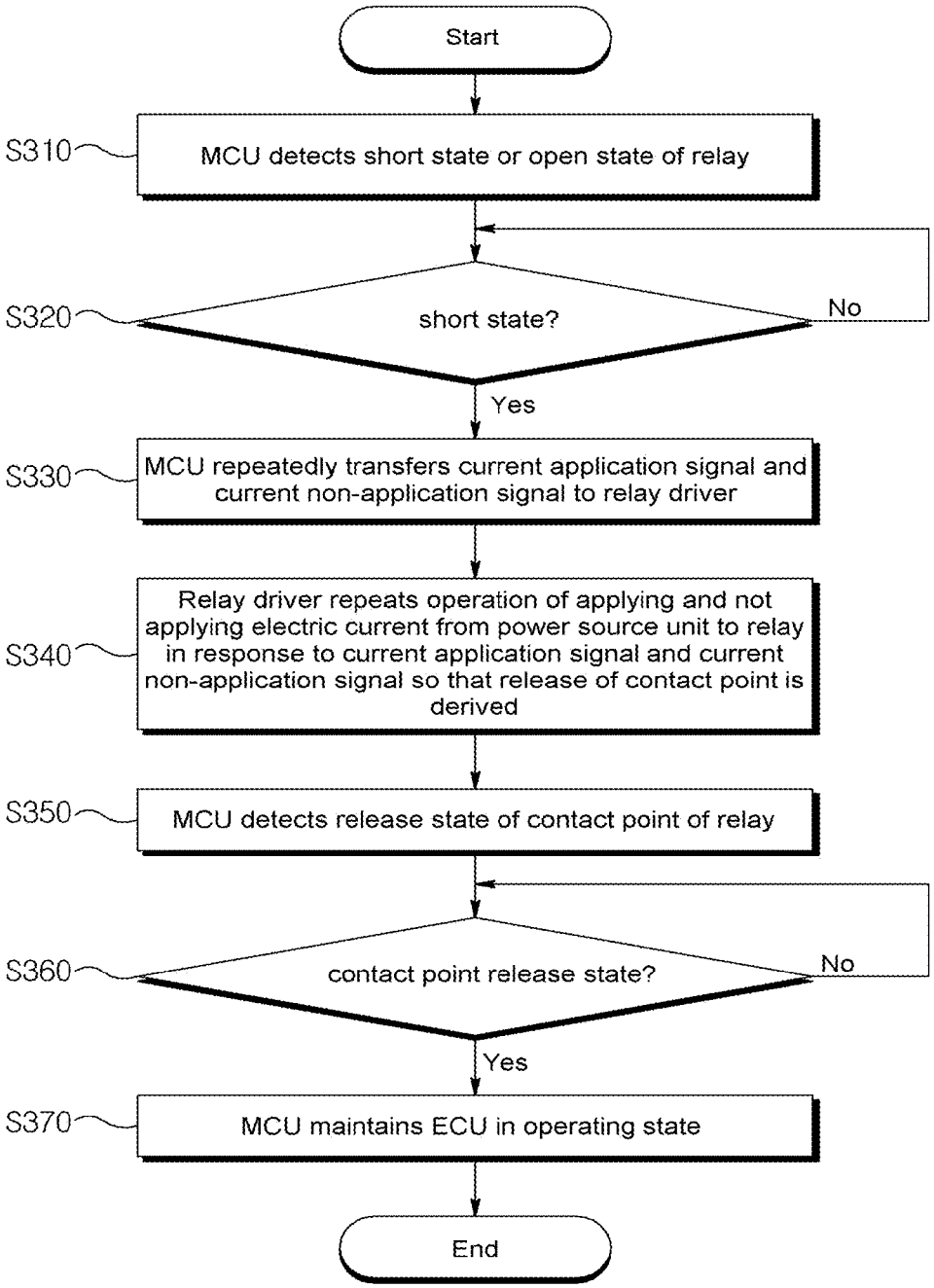

Start
S310
MCU detects short state or open state of relay
S320
short state?
No
Yes
S330
MCU repeatedly transfers current application signal and current non-application signal to relay driver
S340
Relay driver repeats operation of applying and not applying electric current from power source unit to relay in response to current application signal and current non-application signal so that release of contact point is derived
S350
MCU detects release state of contact point of relay
S360
contact point release state?
No
Yes
S370
MCU maintains ECU in operating state
End

FIG. 4

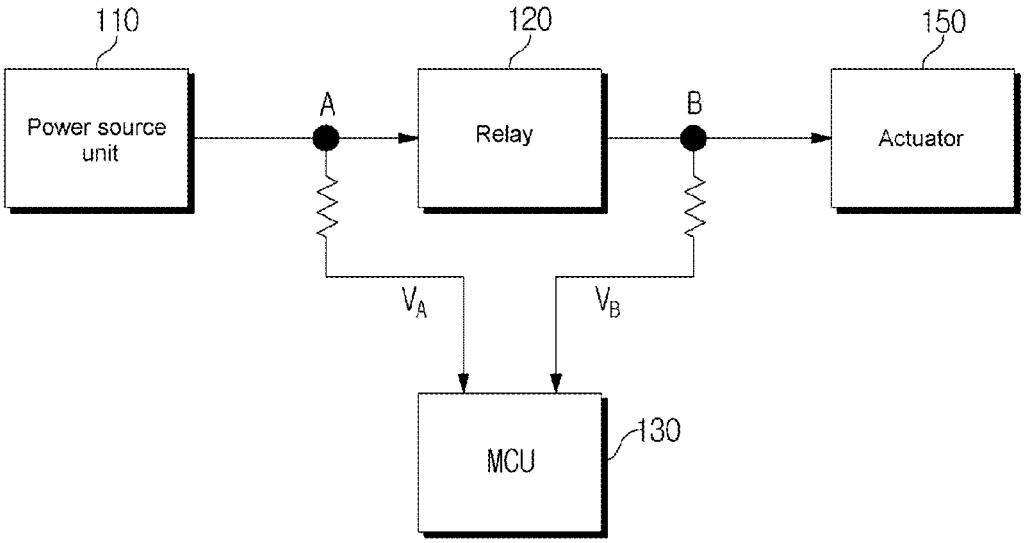
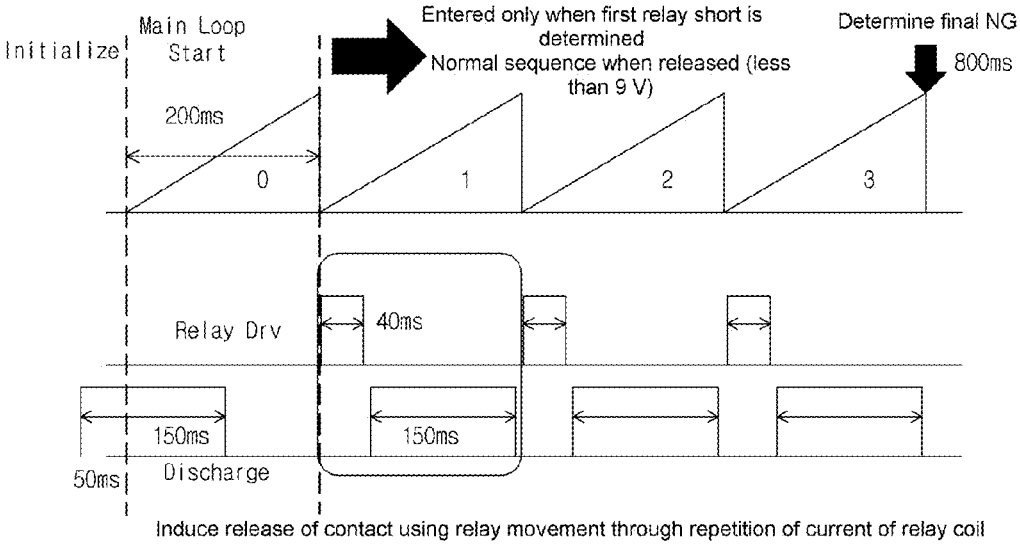

110
120
150
Power source unit
A
Relay
B
Actuator
V_A
V_B
MCU
130

FIG. 5


Initialize
Main Loop Start
Entered only when first relay short is determined
Normal sequence when released (less than 9 V)
Determine final NG
800ms
200ms
0
1
2
3
Relay Drv
40ms
150ms
150ms
50ms
Discharge
Induce release of contact using relay movement through repetition of current of relay coil

METHOD AND APPARATUS FOR RESTORING MECHANICAL RELAY FROM STUCK FAULT TO NORMAL CONDITION

BACKGROUND OF THE INVENTION

1. Field of the Invention

Exemplary embodiments of the present invention relate to an apparatus and method for restoring a mechanical relay used in a vehicle from a temporary stuck fault to a normal condition, and more particularly, to a method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition, wherein if a temporary stuck fault attributable to impurities at the contact point of the mechanical relay or a low temperature is generated in the mechanical relay when an Electronic Control Unit (ECU) detects a failure that may affect a driver, an operation of periodically applying an electric current to the coil of the mechanical relay configured to stop a random operation of an actuator by blocking the supply of an electric current to the actuator is repeated so that heat and an electrical movement are provided, thereby being capable of restoring the mechanical relay from the temporary stuck fault to a normal condition and preventing the ECU from being detected as being a failure.

2. Description of the Related Art

In general, a vehicle is equipped with an ECU configured to receive electrical signals detected by a variety of types of input sensors and to output digital control signals for driving a variety of types of actuators on the output side.

The ECU for a vehicle uses a mechanical relay for a safety function. The mechanical relay functions to stop a random operation of an actuator by blocking an electric current supplied to the actuator when the ECU detects a failure that may affect a driver.

The mechanical relay may be subject to a temporary stuck fault attributable to the impurities of a contact point or a low temperature. An existing safety function is configured to operate after the open/short function of the mechanical relay is checked. If the mechanical relay is temporarily stuck, the ECU determines such a temporary stuck state to be a failure because the operation of the mechanical relay is unable to be guaranteed.

Accordingly, there is a problem in that the failure rate of the ECU may rise depending on a low temperature condition and the lifespan of the mechanical relay because the ECU determines a temporary stuck fault to be a failure when the temporary stuck fault is generated in the mechanical relay due to the impurities of a contact point or a low temperature.

PRIOR ART DOCUMENT

Patent Document

(Patent Document 1) Korean Patent Application Publication No. 1998-054057 (Sep. 25, 1998)

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition, wherein if a temporary stuck fault attributable to impurities at the contact point of the mechanical relay or a low temperature is generated in the mechanical relay when an Electronic Control Unit (ECU) detects a failure that may affect a driver, an operation of periodically applying an electric current to the coil of the mechanical relay configured to stop a random operation of an actuator by blocking the supply of an electric current to the actuator is repeated so that heat and an electrical movement are provided, thereby being capable of restoring the mechanical relay from the temporary stuck fault to a normal condition and preventing the ECU from being detected as being a failure.

In accordance with an aspect of the present invention for achieving the object of the present invention, a method for restoring a relay from a stuck fault to a normal condition in an apparatus including a power source unit, the relay, a relay driver, an MCU, and an ECU includes the steps of detecting, by the MCU, the short state or open state of the relay, repeatedly transferring, by the MCU, a current application signal and a current non-application signal to the relay driver when the relay is in the short state, repeating, by the relay driver, an operation of periodically applying an electric current from the power source unit to the relay in response to the current application signal and the current non-application signal so that the release of a contact point of the relay is induced, detecting, by the MCU, the release state of the contact point of the relay, and maintaining, by the MCU, the ECU in an operating state when the contact point of the relay is released.

In this case, detecting the short state or open state of the relay may include detecting, by the MCU, the short state or the open state based on a voltage difference obtained by comparing voltage at the front of the relay with voltage at the rear of the relay when a power source from the power source unit is supplied to an actuator through the relay.

Furthermore, repeating the operation of periodically applying the electric current may include repeating, by the relay driver, an operation of turning on a switching element in response to the current application signal of a high level so that the electric current is applied from the power source unit to the relay or an operation of turning off the switching element in response to the current non-application signal of a low level so that an electric current is not applied from the power source unit to the relay.

In accordance with another aspect of the present invention for achieving the object of the present invention, an apparatus for restoring a mechanical relay from a stuck fault to a normal condition includes a power source unit configured to supply a power source, a relay configured to supply the power source from the power source unit to an actuator or block the supply of the power source from the power source unit to the actuator, a relay driver configured to execute the supply or blocking of the relay according to a switching operation, and an MCU configured to detect the short state or open state of the relay and to repeatedly transfer a current application signal and a current non-application signal to the relay driver when the relay is in the short state, wherein the relay driver repeats an operation of periodically applying an electric current from the power source unit to the relay in response to the current application signal and the current non-application signal so that the release of a contact point of the relay is induced, and the MCU detects the release state of the contact point of the relay and maintains an ECU in an operating state when the contact point of the relay is released.

Furthermore, the MCU may be further configured to detect the short state or open state of the relay based on a voltage difference obtained by comparing voltage at the front of the relay and voltage at the rear of the relay when a power source from the power source unit is supplied to the actuator through the relay.

Furthermore, the relay driver may be further configured to repeat an operation of turning on a switching element in response to the current application signal of a high level so that the electric current is applied from the power source unit to the relay or an operation of turning off the switching

element in response to the current non-application signal of a low level so that an electric current is not applied from the power source unit to the relay.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagram illustrating the configuration of an apparatus for restoring a mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention;

FIG. **2** is a diagram illustrating the configuration of a circuit using the switching element of a relay driver in accordance with an embodiment of the present invention;

FIG. **3** is a flowchart illustrating a method of restoring, by the apparatus, a mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention;

FIG. **4** is a diagram illustrating an example in which a relay detects a short state or an open state in accordance with an embodiment of the present invention; and

FIG. **5** is a diagram illustrating an example of a driving signal that repeats an operation for periodically applying an electric current to the relay in accordance with an embodiment of the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

The present invention may be modified in various ways and may be implemented to have several embodiments. Specific embodiments of the present invention are illustrated in the drawings and are described in detail in the detailed description. It is however to be noted that the present invention is not intended to be limited to the specific embodiments, but is intended to include all modifications, equivalents, or substitutions which fall within the spirit and technical scope of the present invention.

Embodiments of a method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition according to the present invention are described in detail with reference to the accompanying drawings. In describing the embodiments with reference to the accompanying drawings, the same or corresponding elements are assigned the same reference numerals, and a redundant description thereof is omitted

FIG. **1** is a diagram illustrating the configuration of an apparatus for restoring a mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention.

The apparatus **100** for restoring a mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention includes a power source unit **110**, a relay **120**, a Main Control Unit (MCU) **130**, a relay driver **140**, an actuator **150**, and an ECU **160**.

The power source unit **110** supplies a power source for the operations of the elements of a vehicle.

The relay **120** performs an operation of supplying the power source of the power source unit **110** to the actuator **150** or blocking the power source of the power source unit **110** supplied to the actuator **150**.

The MCU **130** detects the short state or open state of the relay **120**, and repeatedly transfers a current application signal and a current non-application signal to the relay driver **140** when detecting the relay **120** in the short state.

The relay driver **140** executes the power supply or blocking operation of the relay **120** according to a switching operation. That is, the relay driver **140** induces the release of a contact point by repeating a current application and non-application operation from the power source unit **110** to the relay **120** in response to the current application signal and the current non-application signal.

Accordingly, the MCU **130** detects the release state of the contact point of the relay **120**, and maintains the ECU **160** in an operating state when detecting the release of the contact point of the relay **120**.

Furthermore, when the power source from the power source unit **110** is supplied to the actuator **150** through the relay **120**, the MCU **130** may detect the short state or open state of the relay **120** based on a voltage difference obtained by comparing voltage at the front of the relay **120** with voltage at the rear of the relay **120**.

As illustrated in FIG. **2**, the relay driver **140** may include, for example, an NPN type transistor TR**1** as a switching element. FIG. **2** is a diagram illustrating the configuration of a circuit using the switching element of the relay driver **140** in accordance with an embodiment of the present invention. That is, as illustrated in FIG. **2**, the relay driver **140** is configured so that the MCU **130** is connected to the base of the first transistor TR**1**, the emitter of the first transistor TR**1** is grounded, and the relay **120** is connected to the collector of the first transistor TR**1**. The NPN type first transistor TR**1** is turned on/off in response to a relay driving signal output by the MCU **130**.

Accordingly, the relay driver **140** may repeat an operation of turning on the switching element TR**1** in response to the current application signal of a high level from the MCU **130** so that an electric current is supplied from the power source unit **110** to the relay **120** and an operation of turning off the switching element TR**1** in response to the current non-application signal of a low level from the MCU **130** so that an electric current from the power source unit **110** is not applied to the relay **120**. In FIG. **2**, first and second resistors R**1** and R**2** connected in parallel to the output terminal of the MCU **130** and the base of the first transistor TR**1** are resistors for voltage distribution. A first diode D**1** connected to the collector of the first transistor TR**1** and to the coil terminal of the relay **120** is a diode for preventing a reverse current.

That is, when the current application signal of a high level is output through the digital output terminal of the MCU **130**, the current application signal of a high level is input to the base of the first transistor TR**1** of the relay driver **140** through the first and the second resistors R**1** and R**2**.

The first transistor TR**1** is turned on in response to the current application signal of a high level from the MCU **130**, and thus voltage V_B is applied to the coil terminal of the relay **120**. As a result, the coil of the relay **120** is excited, the contact point terminal of the relay **120** is closed, and thus the relay **120** is driven.

In contrast, when the current non-application signal of a low level is output through the digital output terminal of the MCU **130**, the current non-application signal of a low level is input to the base of the first transistor TR**1** through the first and the second resistors R**1** and R**2**. The first transistor TR**1** is turned off in response to the current non-application signal of a low level from the MCU **130**, and thus the relay **120** is not driven in response to the turn-off operation of the first transistor TR**1**.

FIG. **3** is a flowchart illustrating a method of restoring, by the apparatus, the mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention.

Referring to FIG. **3**, first, the MCU **130** of the apparatus **100** for restoring the mechanical relay from a stuck fault to a normal condition in accordance with an embodiment of the present invention detects the short state or open state of the relay **120** at step S**310**.

In this case, the MCU **130** may detect the short state or the open state based on a voltage difference obtained by comparing voltage V_A at the front of the relay **120** with voltage V_B at the rear of the relay **120** when a power source from the power source unit **110** is supplied to the actuator **150** through the relay **120** as illustrated in FIG. **4**. FIG. **4** is a diagram illustrating an example in which the relay **120** detects the short state or the open state in accordance with an embodiment of the present invention.

Thereafter, when the relay **120** is in the short state at step S**320**, the MCU **130** repeatedly transfers a current application signal and a current non-application signal, such as those illustrated in FIG. **5**, to the relay driver **140** at step S**330**. FIG. **5** is a diagram illustrating an example of a driving signal that repeats an operation for periodically applying an electric current to the relay **120** in accordance with an embodiment of the present invention. As illustrated in FIG. **5**, the MCU **130** applies the current application signal of a high level to the relay driver **140** during 40 ms and the current non-application signal to the relay driver **140** during 150 ms in a cycle of 200 ms in which the driving signal is applied to the relay driver **140**. Accordingly, the electric current is repeatedly supplied to the coil of the relay **120** by the on/off driving operations for the relay **120** of the relay driver **140**, and thus the release of the contact point of the relay **120** that has been stuck is derived.

Thereafter, the relay driver **140** repeats the operation of periodically applying the electric current from the power source unit **110** to the relay **120** in response to the current application signal and the current non-application signal so that the release of the contact point is derived at step S**340**.

That is, the relay driver **140** repeats the operation of turning on the switching element TR**1** in response to the current application signal of a high level so that the electric current is supplied from the power source unit **110** to the relay **120** or the operation of turning off the switching element TR**1** in response to the current non-application signal of a low level so that an electric current is not applied from the power source unit **110** to the relay **120**.

Thereafter, the MCU **130** detects the release state of the contact point of the relay **120** at step S**350**. When the contact point of the relay **120** is released (Yes at step S**360**), the MCU **130** maintains the ECU **160** in the operating state at step S**370**.

Accordingly, when a stuck fault is generated in the relay **120**, the operation of periodically applying an electric current to the coil of the relay is repeated so that heat and an electrical movement are supplied. Accordingly, a temporary stuck problem can be solved, and the ECU can be prevented from being determined to be a failure due to the temporary stuck state.

As described above, the embodiments of the present invention can achieve the method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition, wherein if a temporary stuck fault attributable to impurities at the contact point of the mechanical relay or a low temperature is generated in the mechanical relay when the ECU detects a failure that may affect a driver, the operation of periodically applying an electric current to the coil of the mechanical relay configured to stop a random operation of the actuator by blocking the supply of an electric current to the actuator is repeated so that heat and an electrical movement are provided, thereby being capable of restoring the mechanical relay from the temporary stuck fault to a normal condition and preventing the ECU from being detected as being a failure.

In accordance with the present invention, when a stuck fault is generated in the mechanical relay, the operation of periodically applying an electric current to the coil of the mechanical relay is repeated so that heat and an electrical movement are supplied. Accordingly, a temporary stuck problem can be solved, and the ECU can be prevented from being determined to be a failure due to a temporary stuck state.

The present invention may be applied to a method and apparatus for restoring a mechanical relay from a stuck fault to a normal condition, which are capable of restoring the mechanical relay from a temporary stuck fault to a normal condition and preventing an ECU from being detected as being a failure by repeating the operation of periodically applying an electric current to the coil of the relay so that heat and an electrical movement are supplied when the temporary stuck fault attributable to impurities at the contact point of the mechanical relay or a low temperature is generated in the mechanical relay.

As described above, those skilled in the art to which the present disclosure pertains will understand that the present disclosure may be implemented in various detailed forms without changing the technical spirit or indispensable characteristics of the present disclosure. It will be understood that the aforementioned embodiments are illustrative and not limitative from all aspects. The scope of the present disclosure is defined by the appended claims rather than the detailed description, and the present disclosure should be construed as covering all modifications or variations derived from the meaning and scope of the appended claims and their equivalents.

What is claimed is:

1. A method for restoring a relay from a stuck fault to a normal condition in an apparatus comprising a power source unit, the relay, a relay driver, a Main Control Unit (MCU), and an Electronic Control Unit (ECU), the method comprising steps of:

detecting, by the MCU, a short state or open state of the relay;

repeatedly transferring, by the MCU, a current application signal and a current non-application signal to the relay driver when the relay is in the short state;

repeating, by the relay driver, an operation of periodically applying an electric current from the power source unit to the relay in response to the current application signal and the current non-application signal so that a release of a contact point of the relay is induced;

detecting, by the MCU, the release state of the contact point of the relay; and

maintaining, by the MCU, the ECU in an operating state when the contact point of the relay is released.

2. The method according to claim **1**, wherein detecting the short state or open state of the relay comprises detecting, by the MCU, the short state or the open state based on a voltage difference obtained by comparing voltage at a front of the relay with voltage at a rear of the relay when a power source from the power source unit is supplied to an actuator through the relay.

3. The method according to claim **1**, wherein repeating the operation of periodically applying the electric current comprises repeating, by the relay driver, an operation of turning on a switching element in response to the current application signal of a high level so that the electric current is applied from the power source unit to the relay or an operation of turning off the switching element in response to the current

non-application signal of a low level so that an electric current is not applied from the power source unit to the relay.

4. An apparatus for restoring a mechanical relay from a stuck fault to a normal condition, comprising:

a power source unit configured to supply a power source;

a relay configured to supply the power source from the power source unit to an actuator or block the supply of the power source from the power source unit to the actuator;

a relay driver configured to execute the supply or blocking of the relay according to a switching operation; and

a Main Control Unit (MCU) configured to detect a short state or open state of the relay and to repeatedly transfer a current application signal and a current non-application signal to the relay driver when the relay is in the short state,

wherein the relay driver repeats an operation of periodically applying an electric current from the power source unit to the relay in response to the current application signal and the current non-application signal so that a release of a contact point of the relay is induced, and the MCU detects the release state of the contact point of the relay and maintains an Electronic Control Unit (ECU) in an operating state when the contact point of the relay is released.

5. The apparatus according to claim **4**, wherein the MCU is further configured to detect the short state or open state of the relay based on a voltage difference obtained by comparing voltage at a front of the relay and voltage at a rear of the relay when a power source from the power source unit is supplied to the actuator through the relay.

6. The apparatus according to claim **4**, wherein the relay driver is further configured to repeat an operation of turning on a switching element in response to the current application signal of a high level so that the electric current is applied from the power source unit to the relay or an operation of turning off the switching element in response to the current non-application signal of a low level so that an electric current is not applied from the power source unit to the relay.

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